BOTANICAL GAZETTE

APRIL, 1894.

Artificial cultures of an entomogenous fungus.

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WITH PLATES XIV—XVI.

While making collections in a ravine near Ithaca, N. Y., known as Coy glen, on October 28th, 1893, a specimen of *Isaria farinosa* (Dicks.) Fr. was found upon an arctid chrysalis nestling in the leaf mold, the sporophores of the fungus just projecting above the loose leaves. This plant usually consists of several sporophores, 1–2^{mm} in diameter and 2–4^{cm} in height, issuing from the host. The slender portion of the sporophores, constituting two-thirds to three-fourths of their length, is from whitish to pale yellow or orange yellow in color; while the clavate portion, upon which the fructification is borne, is 2–4^{mm} in diameter, white in color and farinaceous in texture upon the surface. A section of the clavula shows that the interior consists of a mass of hyphæ in arrangement and color similar to those of the sterile portion of the sporophore, being composed of very slender threads lying close together in irregular parallel series. Toward the outer portion of the clavula the threads which arise as branches from the central bundle are whitish and very loosely arranged, forming a fluffy mass. The threads of this fluffy portion branch profusely in a monopodial fashion at first. The terminal branches, very short usually, arise either singly, or opposite, or in whorls. Upon the ends of these final branches the lanceolate basidia are borne in pairs or groups of a varying number. The basidia are surmounted by slender sterigmata which produce the spores in chains much in the same fashion as they are borne in species of *Penicillium*. Indeed the spore clusters when separated resemble very closely the fructification of some species of this genus. The spores are short elliptical or usually rounded, and measure about 2μ.

Upon reaching the laboratory with the material an attempt was made to cultivate the fungus in ordinary culture media. Accordingly dilution cultures were started in the usual way for the separation of the organism in agar-agar peptone broth, the three dilutions made in culture tubes being poured into Petrie dishes. The cultures were started at about 5 P. M. on the same day as the collection was made, Oct. 28th. On the following morning an examination was made at 10 A. M. No spores were seen which had germinated, though a very thorough search was not made. Oct. 30th, at 9:30 A. M. a second examination was made. Numerous spores had germinated and growth was progressing finely. One or two germ tubes issue from a single spore, and their points of origin, when there is more than one, may be on opposite sides of the spore or on the same side. The general course of the threads at first, when branching does not occur, is quite straight, but the outline of the thread is variously sinuous. Septa probably occur at this stage but they could not be observed while examining the culture in the agar. The protoplasm is very finely granular, and appears to be massed together in certain parts of the thread and spore, the other spaces being occupied with a homogeneous or watery substance. The study of the stages of germination was made from culture no. 1 by placing the Petrie dish upon the stage of the microscope. The spores on the sporophores of the fungus were so numerous and the material was in such a fresh condition that very few foreign organisms appeared in dilutions 1 and 2, while dilution no. 3 was pure, and the separation was effected without any difficulty. From this separation pure cultures were started by transplanting the fungus to culture tubes of ordinary agar, bean stems, and potato. In fact pure cultures were also obtained by touching a flamed platinum needle to the spores on the clavula of the sporophore and then thrusting it into nutrient agar. But the separation was considered necessary in order to have proof in the case of such small germs that the growth obtained was that of the desired plant by watching the germination of the spores and the development of the colonies from these isolated centers in the dilutions.

The fungus grows quite rapidly on artificial media in the culture tubes, soon forming on the surface of the medium a dense velvety growth with quite a long pile. On oblique

slices of potato the larger part of which is exposed, partly dry and not in close contact with the sides of the tube, the fungus spreads quickly, and extends more slowly through the substance of the potato to the surface which is in closer contact with the culture tube, and which is quite moist from the excess of water on the bottom and the side of the tube to which it gravitates as the tube is kept in an oblique position. As the watery infusion gradually disappears by slow evaporation and by being absorbed by the growth of the fungus, the threads appear on the other side of the potato. Now since there is a less content of water and the substance has lost some of its richness, the fungus does not grow so profusely nor so rapidly. There is then a tendency to grow into sporophores composed of numerous parallel threads which arise from the surface of the substratum in the same manner as the normal sporophores of the Isaria stage on the natural host, the pupa of the insect. The large majority of these sporophores on potato are much shorter than those on the insect, but they are also much stouter, the diameter being two to four times that of the sterile portion of the sporophore as it appears in nature. From ten to forty of these sporophores may arise from an ordinary sized piece of potato in a culture tube and they are of an orange buff, or buff yellow color. Many of these are from 2–4^{mm} high, while still others are 6–10^{mm}, and they may be divided at the free extremity into several portions. In one culture a very large sporophore was developed which became at length fully 3^{cm} long. It arose perpendicular to the surface of the potato and thus nearly perpendicular to the side of the tube so that when it was 6^{mm} long it came squarely against the wall of the tube. Here the end remained fixed and it appeared for a time as though the sporophore would not grow any longer. From the outer surface of the end which was in close contact with the wall numerous fine radiating threads of the fungus grew out over the inner side of the tube for quite a distance. At the base of this growth the surface presented the farinaceous appearance characteristic of the fructification. In the course of a week it was observed that the sporophore had continued to grow in length and was turned to one side so that its course was downward in the tube. This continued until the entire length of the sporophore was 3^{cm}. At various places it appeared to halt and send out a thin membranous expanded

growth, closely attached to the side of the tube, showing the color of the sterile portion next the wall of the tube, and, on the opposite side, possessing the farinaceous appearance of the fruit. Eventually from several of these expanded portions of the sporophore elongated, radiating, branched, terete fruiting portions were developed, which altogether formed quite a complicated condition of this phase of the plant.

Probably the reason that so many of the sporophores on the potato were very short was due to the fact that the moisture almost entirely disappeared before they were perfected. In every case, however, the free ends of these sporophores were covered with the characteristic fructification.

While no characteristic sporophores are developed at first when there is a large water content and the profuse growth of the fungus forms a long pile covering the substratum, yet spores are developed in great numbers. From these spores on a potato culture pure dilution cultures were started in nutrient agar, in order to study carefully the characteristics of growth and the appearance of the colonies in the artificial medium, as well as the peculiarities of the fructification formed when the sporophores are absent. Dilution cultures were made in order to have the colonies properly separated in the plate. Three dilutions were effected December 28th, at 5:30 P. M., and were poured in Petrie dishes. From no. 1 the study of germination and the development of the colonies was made. December 29th, at 12:30 P. M., the culture was examined. Only a few of the spores were germinating at this time. Those which were immersed in the agar were hyaline in appearance. A few spores here and there were not wholly immersed in the medium, probably owing to the fact that they were dry when the dilutions were made and did not absorb sufficient moisture to permit all of them to sink readily in the liquid. These spores appeared quite dark, as if the wall was dark in color, which resulted from the strong refraction of the light. When these superficial spores germinated, the germ tube penetrated the medium and was hyaline in appearance. Prior to germination the spores swell considerably so that the diameter of the spore is nearly twice what it is when the spores are matured or before they are placed under conditions favorable to germination. Those measured showed a diameter of 3–3.5 μ. The germ tubes were little more than 2 μ in diameter.

On December 30th the culture was examined again. Many

spores had by this time germinated, one to two or three tubes having arisen from a single spore. Branching also by this time was taking place quite freely. Rather faint vacuoles appear in the thread at quite regular intervals as if in the middle of the cell, the transverse walls of which are hard to distinguish in the agar. By December 31st the growth had increased sensibly and the branching was becoming quite profuse while some of the shorter branches were being elevated in the air, but there was as yet no evidence of spore formation.

When the colonies become perceptible to the unaided eye the surface ones are circular, quite compact, and with very fine numerous radiating lines on the margin, giving it a finely fimbriated appearance. When young the deep seated colonies are apt to be angular so that many of them are triangular in form. As the colonies age the superficial ones, or those which reach the surface by later growth, become convex by the elevation of numerous threads which give it a whitish fluffy appearance at the center, while at the margins it is still finely fimbriate from the radiating threads. While the colonies are quite young they resemble those of a species of *Penicillium*, probably *P. glaucum*, which appeared accidentally in culture no. 3. In plate XIV, figs. 2, 3, 4, this single colony of Penicillium can be easily differentiated from the colonies of Isaria, but in fig. 1 it is impossible to do so except by selecting the corresponding location of the colony in the plate, all the four photographs of the cultures being from the same dish at successive stages of growth. When the Penicillium colony fruits the sporophores are quite long and erect and are so arranged that open spaces appear here and there through which the light passes more easily than at other places and a strong differentiation between light and shade appears over different parts of the fruiting portion of the colony. There is also very little of the fluffy arrangement of the aerial hyphæ, such as occurs in the Isaria colonies.

As the colonies of Isaria become more and more elevated from the medium they become mealy white in appearance from the numbers of spores produced, mixed with the mass of cottony threads. The appearance of the colonies may be varied somewhat by periodic growth, induced by variations in the temperature. Some tests of this were made with the culture no. 3 of the dilution for the separation of the fungus.

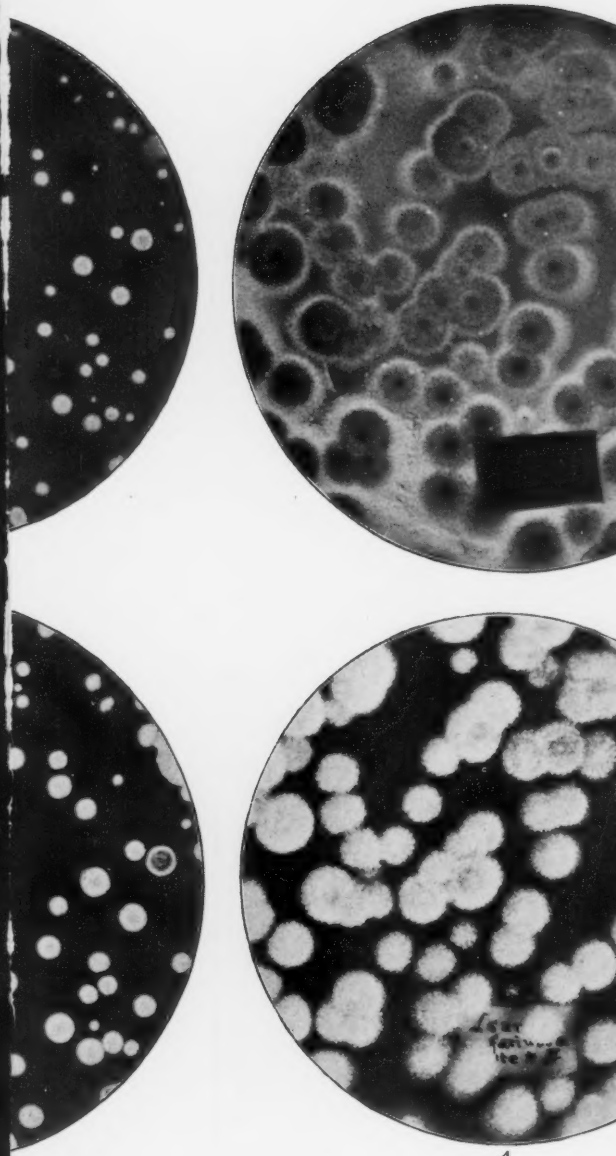
After growing for some time in a rather cool room, at a temperature ranging from 15–18°C., the culture was placed in the thermostat with a temperature of 25.6°C. In a few days a profuse growth had taken place, making a distinct concentric ring. At the center was a strongly convex dense portion, separated from an outer ring which was elevated above the intervening portion. In the thermostat at the higher temperature this ring frequently became elevated considerably above the center of the colony. The margin of the colony presented a larger corona of radiating threads than would have appeared had the culture been kept at the lower temperature for the same time.

By January 12th the colonies from the pure culture started Dec. 28th, examined with a low power of the microscope, show the loose cottony mass to be composed of numerous interwoven threads bearing short sporophores consisting of a single thread. Usually these were arranged in a monopodial fashion but sometimes they were opposite. These correspond to the ultimate branches of the external layer of the clavula on the natural sporophores. Like them they are surmounted by several short lanceolate basidia, the sterigmata of which bear long chains of spores, reminding one very forcibly of the fructification of a *Penicillium*, though on shorter sporophores.

The illustrations in plate XIV are natural size reproductions of culture no. 3 at different stages of growth. In figs. 1 and 2, the colonies were not yet elevated above the medium, and, being transparent and very delicate, could not be photographed by reflected light to show the peculiar characters. In figs. 3 and 4, the colonies were elevated at the center above the medium. Figure 3 was photographed by transmitted light to show the finely fimbriated margin of the colonies and the relation of the same to the denser portion of the colony. This photograph is not as good as it should be under favorable circumstances, since by this time the medium had become milky in color from the entrance of some species of bacteria which had accidentally gotten into the culture, a small colony of which can be seen on the upper right margin. The light transmitted through the milky portion of the medium also affected the sensitive plate and the differentiation between the colonies and the intervening spaces was not strong. It is sufficiently so, however, to show

1

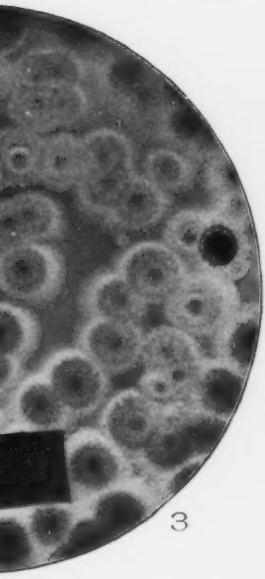
2



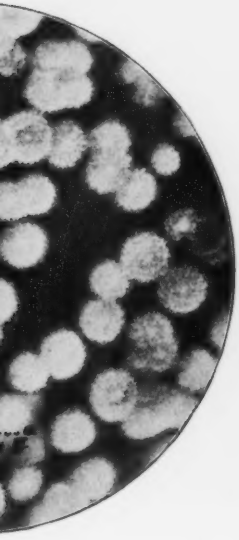
4

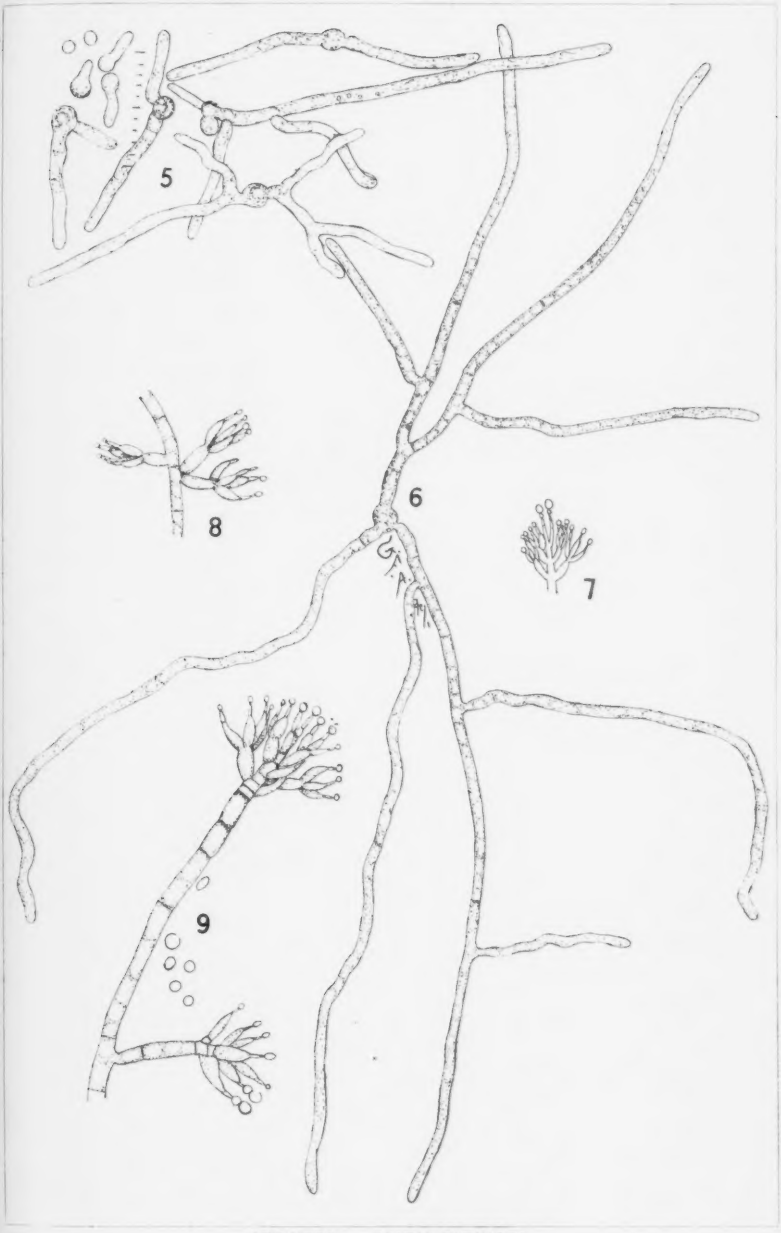
ATKINSON on ISARIA FARINOSA.

PLATE XIV.



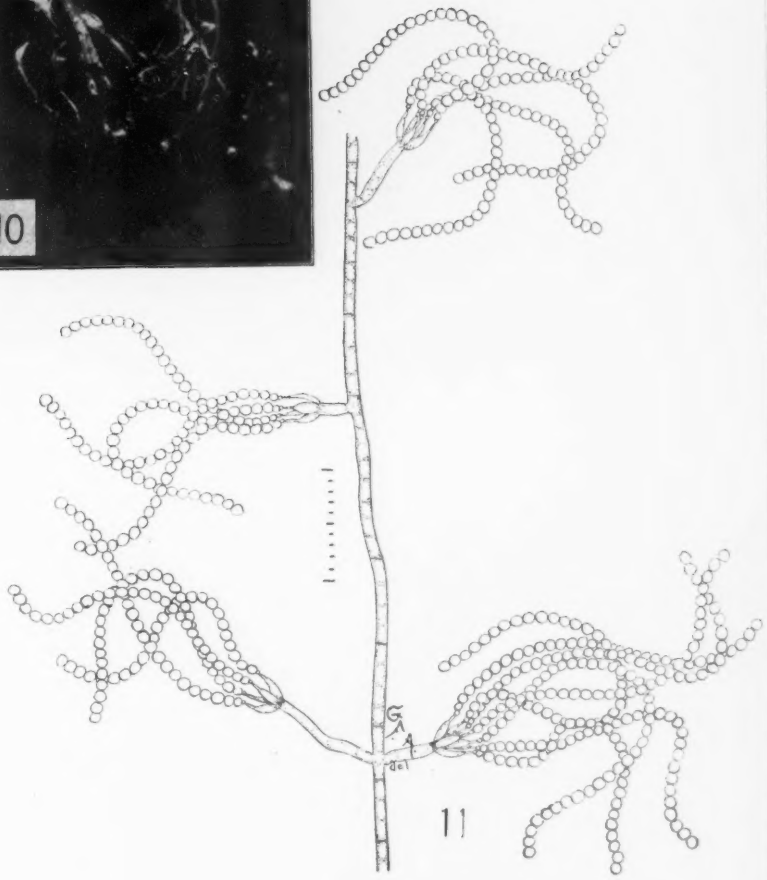
3





ATKINSON on ISARIA FARINOSA.

THE
JOHN CREAR
LIBRARY



ATKINSON on ISARIA FARINOSA.

the character of the margin of the colonies. By transmitted light the elevation of the colonies could not be shown. This can be done by photographing in the ordinary way by reflected light. Such a photograph taken on the same day is reproduced in figure 4, of the same plate. The margin of the colonies, however, is not shown by this process, but a knowledge of the true character of the colonies can be obtained by putting the two photographs together.

Several cultures on artificial media in culture tubes have been made but in no case has any thing resulted which shows the perfect or ascigerous stage of the fungus. Upon nutrient agar, nutrient gelatine, and bean stems, nothing but the cottony or fluffy growth, covered by the farinaceous fructification, appears. On potato this growth first appears, to be succeeded by the characteristic fructification of the Isaria stage.

Tulasne has shown[1], not by cultural experiments, but by contiguity of development, that *Isaria farinosa* (Dicks.) Fr. is the conidial stage of *Cordyceps militaris* (Linn.) Link. A large number of cultures, perhaps varying the substratum and other conditions of environment, might result in the development of the Cordyceps form in artificial cultures from the Isaria stage.

The fact that the Isaria stage will develop readily on various media such as described above is evidence that it can develop readily as a saprophyte, and is thus more likely to be preserved in greater abundance and in wider distribution than if it were able to propagate itself only on insects.

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EXPLANATION OF PLATES XIV–XVI.

PLATE XIV.— Fig. 1. Photograph, nat. size, by transmitted light, of plate culture in agar, showing colonies.—Fig. 2, same at more advanced stages of growth.—Fig. 3, same at still more advanced stage showing the fimbriated margin of colonies.—Fig. 4, same by direct light to show elevation of colonies.

PLATE XV.—Fig. 5, germinating spores.—Fig. 6, farther advanced stage.—Fig. 7, group of fruiting basidia from sporophore of plant developed under natural conditions.—Figs. 8 and 9, same, from culture on agar.

PLATE XVI.—Fig. 10. Photograph of Isaria farinosa from which cultures were started; magnified twice.—Fig. 11, fructification in elevated portion of colony on agar.

In plates XV and XVI the scale shown is 1 mm magnified about 18 times. Figs. 5, 6, 7, 8, 9, 11 are magnified 50 times more than the scale. Drawn by aid of camera lucida.

[1]Note sur les Isaria et Sphæria entomogenes. Ann. d. Sci. Nat. Bot. IV. **8**: 35. 1857.—Torrubia militaris. Selecta Fung. Carp. **3**: 6. 1865.

On the absorption of water by the green parts of plants.

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Notwithstanding many experiments, the question as to whether land plants absorb any considerable quantities of water through their green parts is still unsettled. It is to be noticed that the two extremes of absorption, i. e., the absorption of the major part of the water supply on the one hand, and of extremely minute and physiologically unimportant portions on the other, are here not brought into discussion. The first is settled beyond all doubt in the negative, and the second is of comparatively little importance and appears to be beyond any of the methods of investigation yet applied to it. But to know whether plants can under any normal conditions absorb water through green parts to an extent sufficient to profitably supplement the root supply, is of much general interest, even though, as a side question upon which nothing of consequence depends, it is of no great scientific moment.

The belief in the affirmative of the problem is very old and wide-spread, perhaps indeed nearly universal among gardeners and others dealing in a practical way with living plants. Its principal basis is the familiar fact that plants drooping through loss of water by too rapid transpiration revive if sprayed in the ordinary fashion. But if the conditions of this spraying be controlled and varied by experiment, the relationship of cause and effect is found to be quite different from that which is apparent. If (as has incidentally happened in some of the experiments presently to be described) the water be kept from the roots and the damp atmosphere created by the spray be soon removed, the plant does not revive. Or if the damp atmosphere be retained and the plant revives, its weight is found not to have increased, but rather diminished, as the following shows:

Exp. a. Healthy young *Ricinus*, the pot and earth wrapped in rubber cloth, was kept in a dry window one day until it was drooping for want of water. Then weighed 372 ^{gm}. Placed in bell-jar moistened within, in twenty-four hours it had completely revived, but weighed 369.430 ^{gm}.

Or again, if a plant be used which has wilted not through too rapid transpiration, but through slower loss of water so

that the soil has become dry, and if the soil be protected, it will not revive at all when sprayed and kept in a damp atmosphere. The explanation of these facts seems to be that the rate of supply of water to leaves by conduction from roots has a maximum which may be exceeded under the same conditions by the rate of loss through transpiration, and when this occurs drooping follows. To plants in this condition spraying, when it does not directly water the earth, creates a moist atmosphere which is for some time maintained by evaporation of the clinging water-drops; transpiration is thereby diminished until it is equalled and exceeded by conduction, and revival follows. But when the drooping is the result of absence of water at the roots, these being protected no revival can follow the spraying except by direct absorption through the green parts; and the fact that in such cases no revival takes place is fair evidence that absorption through the green parts cannot, to any appreciably profitable extent, occur. That the revival of drooping parts can and does follow simple diminution of too rapid transpiration without addition of water, is shown upon a large scale out of doors in gardens when hot summer days are followed by cool evenings, and still better, in the irrigated regions of the west, in both of which cases there is an evening revival of parts which drooped under the heat and brightness of the day.

So much for the popular notion. In scientific circles there has been less unanimity. The earliest experiments of importance were those of Duchartre (1861),[1] who, starting with the idea that plants absorb dew through their leaves and wishing to measure its amount, was led by his experiments to conclude that practically they do not absorb dew or mist. His trials were mainly with entire plants, and carefully made. In 1878 Boussingault published[2] the results of his studies, which were largely upon cut plants, concluding that absorption does take place through green parts. In the meantime Henslow had been carrying on independently similar studies with similar but even more positive conclusions, and these were published shortly after.[3] Sachs in his "Lectures on the Physiology of Plants"[4] gives his opinion that the "numerous

[1] Bull. Soc. Bot. de France, **4**:—.—.
[2] Ann. de Chimie et de Physique. March, 1878.
[3] Journ. Linn. Soc. (Bot.) **17**:313–327. 1879.
[4] Engl. Ed. p. 254.

researches directed to this end [i. e., absorption through leaves] have yielded no satisfactory results whatever," and that it is not proven "that any considerable quantities of water, and salts dissolved in it, are conveyed by means of the leaves of the land plants, and that the activity of the roots and of transpiration is supplemented by this means." Vines in his "Lectures"[5] devotes a couple of pages to the subject and concludes that while under special conditions such absorption may take place, "the evidence before us is insufficient to prove that the absorption of water is an important normal function of leaves." Nothing further of importance appears to have been published of late.[6]

The paper by Henslow above cited as being the latest and most positive and as well the basis of the tests to be presently described, requires some analysis here. In reviewing the work of Duchartre, he contends that the phenomena shown by a cut shoot are a safe guide to the phenomena shown by the entire plant. But it is best to quote his exact words,[7] which are these: "It is easy to prove that all the functions of a leaf *are* carried on when detached as when growing;" and again, "all that can be called injurious to a shoot when detached for experimental purposes lasting for a short time only, is that the supply of water is cut off. The shoot may become flaccid and slightly enfeebled, but in no sense are its functions impaired. And I maintain, making due allowance for that fact, whatever results a cut shoot or detached leaf gives in the matter of absorption and transpiration, they *are* [sic] legitimately applicable to a growing plant. Those who assert it to be otherwise must bear the burden of proof."[8] It is not surprising after these statements, that this writer considers the results of his many experiments upon cut shoots as applicable to normally growing plants, and that he therefore con-

[5] Pp. 65–67.

[6] In Science, July, 29, 1893, Mr. E. A. Burt publishes some notes which show that cut shoots absorb some water. He also thinks that some absorption takes place in uninjured plants at night, but his experiments do not seem conclusive on this point.

[7] Op. cit. pp. 314, 315.

[8] According to this contention, if a cut shoot could be supplied with a water supply equivalent to that which it has before cutting, it could continue to act normally in its water relationships for an indefinite period. Mere dipping in water is of course not enough, as root pressure is absent. But I have attached tubes to the cut petioles of leaves, giving them a pressure of a column of three to four feet of water, and they remain fresh but little longer than those merely placed with the cut ends in water.

cludes: "There are ample reasons for believing that dew and rain are under certain circumstances absorbed and utilized to supplement the root supply."

Whatever may be thought of the relationship of Henslow's experiments to his conclusion, this much seems to be clearly shown by the former, that cut shoots do absorb water through their green parts. Many of his experiments have been repeated with results similar to his.[9] But when very similar methods have been applied to uninjured shoots attached to their parent plants, the results (I may so far anticipate as to say) have been different; from which, together with other considerations, it seems that there is a marked *qualitative* difference between the behavior of injured and uninjured plants and parts of plants with reference to their power of absorption of water through their green parts, and that no conclusions can be safely drawn from results in the one case, as to the conditions in the other.

In order to test Henslow's conclusions, and to contribute to the settlement of this problem, I have carried out a rather elaborate series of experiments; and although the results are not so complete and positive as was hoped, they nevertheless have value in this direction.

In experimenting upon entire plants some method of preventing access of water to roots and soil is necessary. This can be conveniently done by use of dentists' rubber cloth; a comparatively small hole therein can be stretched so as to pass over the entire pot and yet shrink so as to clasp the stem above, where it can be further secured by winding with waxed thread. The folds of the rubber may then be gathered beneath the pot and tied. The result can be a water-tight isolation of the entire pot and contents, which is not necessarily injurious to the plant,[10] and this was the method used in the following experiments. Often to prevent access of water to soil in spraying, etc., the plant was laid and kept on its side. When it was needful to keep up a con-

[9] As also by Mr. Burt in the paper mentioned in foot note 6.

[10] Plants thus kept for weeks or even months have been healthy and clean at the end. On the other hand, there sometimes appeared a sudden and very marked "rubber disease." At the contact of rubber and stem, the latter would turn dark, shrink greatly and become dry. I could find no constancy in its appearance. It is worth study. All such plants were of course at once rejected. Late in the course of experiments, it was found that the rubber allows water vapor to pass through it especially when stretched, but it is believed that any error from this source cannot be great enough to materially affect the accuracy of the results.

stant supply of water both day and night to wet surfaces, it was done by connecting them by means of short ribbons of filter paper with beakers kept filled with water. All cases of comparative wetting, etc., were judged by other and disinterested persons. In all weighings allowance was made for withered leaves, etc. Some of the experiments were conducted in large Wardian cases, others in bell jars. When it was needful to keep the air in the latter saturated, it was done by use of wet sponges as well as by shallow dishes of water. Those experiments which are described below are the best from a very large number. There were a few cases in which contrary results were obtained, but in all such, some error could have (or was known to have) come in.

For convenience, the experiments were divided into four divisions:

1. Absorption from wet surfaces.
2. Absorption of water supplied in drops, as rain.
3. Absorption from a quantity of liquid water.
4. Absorption of water-vapor.

1. Do uninjured plants through their green parts absorb water from wet surfaces?

Exp. b. Strong plant of *Senecio petasites*; herbaceous, broad-leaved, 2^{ft} high, branching just above base into two nearly equal stalks. Of one stalk about half its length was wrapped with filter paper kept constantly wet. In open air of room. Second day, traces of drooping in unwrapped stem; third day, leaves drooping on both stems, slightly less on wrapped stem; fifth day, leaves much wilted on both, no discernible difference; sixth day, greatly wilted; tenth day, all leaves dry and withered and stems drooping; a disinterested person could not tell which was most wilted.

Exp. c. Three strong plants of same species of Senecio all $20–24^{in}$ high, in two pots previously treated alike; in the one, two plants, one single stalked, other three-stalked from near the base, in other pot single stalked plant. All three stalks of three-stalked plant were closely wrapped throughout, including even the leaf-axils, with filter paper constantly kept wet. In open air of room. Second day, no change; third day leaves showing signs of drooping in all three plants; fifth day, leaves drooping equally on all stalks; seventh day leaves all drooping and nearly equally, if any difference, somewhat less in wrapped stem; all continued to wilt and stems to droop until all were dead and no marked difference between them.

Exp. d. Two plants of *Hura crepitans* in separate pots, previously treated alike; stem of one wrapped completely with filter paper, kept wet. Other unwrapped, placed under large bell jars open at top; first day, no change, both vigorous; fifth day, lower pair of leaves drooped to wilting in each case; eighth day, leaves wilting on both, but no difference between them; tenth day, both wilting, but no marked difference, if any the wrapped stem rather more drooped; both continued to wilt until dead, but neither more rapidly than the other.

Exp. e. Three plants of *Coleus* sp?; common little-colored variety: 1 with three long internodes wrapped in filter paper kept wet; 2, unwrapped; 3,

five *leaves* out of its twelve had filter paper pressed against both surfaces and kept wet. Placed in large Wardian case: third day, all drooping both leaves and stem, but less in no. 3; tenth day, no perceptible difference between 1 and 2, but from no. 3 leaves have dropped, though stem in better condition than in 1 and 2. Continued until all dead, with no marked difference between 1 and 2.

In all of the above cases, and in others not here described, the wrapped plants acted precisely as if the wet paper were not present; in other words they showed no signs of ability to "supplement their root supply" from this source. How very different is their behavior in comparison with that of Henslow's cut shoots exposed to very similar conditions!

2. Do uninjured plants through their green parts absorb water supplied to them in drops by spraying (or rain)?

Exp. f. A *Coleus* 8in high, allowed to dry slowly in Wardian case until drooping, i. e., through partial exhaustion of root supply; wrapped in rubber, wt. 158.-310gm; laid on side and sprayed with water for several minutes, completely drenched; watched for two hours; it had dried and weighed 158.220gm, and had not revived in the slightest.

Exp. g. Young *Pelargonium* dried slowly in Wardian case until leaves drooped; wrapped in rubber and laid on side and thoroughly drenched with spray; during and after drying it did not revive in the slightest.

Exp. h. Very fine young *Begonia* in small pot, with many leaves and splendid development of trichomes; wrapped in rubber, wt. 206.915gm; sprayed 5 min. with distilled water until drenched; left not in sunlight for 24 hours in Wardian case, wt. 204.815gm; again heavily sprayed as before; in two hours dry or nearly so, wt. 204.675gm; then placed in a saturated bell jar for three days, wt. 203.005gm.

Exp. i. Healthy young *Begonia;* wrapped in rubber, and kept in Wardian case until it drooped slightly, wt. 179.090gm; sprayed thoroughly and at once put in a wet bell jar; next day, wt. 179.070gm: four days later, 178.250gm and no revival of the drooping leaves.

Exps. various. Other *Begonia*, *Coleus* and *Hura* plants, allowed to dry slowly until drooping, then sprayed until dripping with water and allowed to dry, when water was kept from the roots, always failed to revive, and when weighed always showed a loss.

It is of course true, that in any or all of these cases, very small quantities of water may have been absorbed. But it seems plain that no quantity of physiological importance could be taken by the plants from that so abundantly supplied to them. The evidence of the weights shown by the balance is of course of minor value, as transpiration might lessen the weight more than the absorbed water (if any) could increase it; but where transpiration in a thirsting plant is reduced to a minimum in a wet jar and a loss of weight follows, it seems to be certain that no absorption sufficient to be of use to the plant can occur.

3. Do uninjured plants, through their green parts, absorb from a quantity of liquid (hydrostatic) water?

Exp. j. Vigorous young *Helianthus*, 14^{in} high, was allowed to droop for want of water until it bent over to the table. Its top, containing four young leaves and the bud, was allowed to dip into a basin of water, leaving two lower leaves in the air. It showed no trace of improvement and soon died.

Exp. k. Two vigorous *Helianthus* plants, each about 18^{in} high, allowed to droop for want of water until they bent over in a curve to the table. The two large lower leaves of each were then placed in a basin of water while the tops with their leaves were left outside. Whole placed in Wardian case where transpiration could not be too rapid. Both plants continued to wilt until dead, the leaves in water turning yellow and soon dying also.

Exp. l. Young *Begonia* with two strong leaves, one placed in basin of water, one not; whole placed under a bell jar open at top; plant continued to wilt until it died.

On this division of the subject, the experiments are too few and inconclusive, but this is perhaps of the less importance, since such absorption could have very little opportunity to occur normally in nature. Henslow found that an uninjured plant of *Mimulus moschatus* lived for months after one of its shoots had been immersed in water, but this was plainly by virtue of the adventitious roots which it put forth.

4. Do uninjured plants, through their green parts, absorb water vapor?

Exp. m. Strong young *Pelargonium*, wrapped in rubber cloth, weighed complete 187.104^{gm}; dried rapidly by current of air dried by $CaCl_2$ until in two days it weighed 181.186^{gm}; then in Wardian case three days, wt. 180.135^{gm}; then in wet chamber, nearly saturated; in one day wt. 179.552^{gm}; in three days, 178.732^{gm}; four days, 178.212^{gm}; seven days, 176.830^{gm}; and many new leaves appearing[11]; nine days, 175.920^{gm}; continued to decrease steadily in weight for two months until it died.

Exp. n. Young but well-rooted *Coleus*, wrapped in rubber cloth, weighed 182.645^{gm}; dried in open bell jar for four days, weighed 181.802^{gm}, drooping; placed in saturated bell jar; after one day, wt. 181.376^{gm}; two days, 180.744^{gm}; continued to lose weight, dropping old leaves and putting out new ones until it died.

Exp. o. Strong young *Coleus*, wrapped in rubber, all old leaves removed, plant left in Wardian case several days to recover; put out new leaves; then put in a saturated jar and it lost weight until it died. Young *Pelargonium* acted similarly.

Exp. various. Several plants died for want of water in an atmosphere saturated with it.

These latter experiments prove nothing new, but they have their value in this connection as showing forcibly that a plant may die for want of water in an atmosphere saturated with it. If the absorption of water vapor were an "important normal function of leaves" this ought not to be so rapid and positive as it is.

[11] This was several times noticed, and is referred to by Henslow, who thinks that young leaves are a medium of absorption, and are hence put out in greater numbers when water from the air is needed. It is also worth remark that some evidence was observed indicating that when a leaf attached to its plant is injured, it may absorb water through the injury.

Of the whole subject, in summary, it may be said, that while these described experiments may appear to be too few and too imperfect to justify conclusions applicable widely to living plants under entirely natural conditions, nevertheless, made as they are upon fairly representative plants, they seem to render it very improbable that the absorption of water through their green parts is at all general or appreciable in amount among ordinary land plants. Whether in plants of special habit, with special structures which may be used for the purpose (as epiphytic Bromeliaceæ, etc.), such absorption takes place is another and distinct question, and in some cases has proved, and in others may prove, answerable in the affirmative, consistently with an equally emphatic negative for ordinary land plants.

Phanerogamic Laboratory, Harvard University.

The Ware Collection

of Blaschka glass models of flowers at Harvard.

WALTER DEANE.

In the botanical museum of Harvard University is to be seen a collection which is absolutely unique in every way. It is the Blaschka Glass Flower Collection, presented by Mrs. Elizabeth C. Ware and Miss Mary L. Ware, in memory of Dr. Chas. E. Ware, of the class of 1834. These flowers are intended to illustrate the typical forms of phenogamic vegetation in America, and certain forms of the cryptogams will also be represented. The work is being done by the artists, Leopold and Rudolph Blaschka, father and son, living in Hosterwitz, Germany. It was through the untiring energy of Dr. Geo. L. Goodale that these artists were induced to abandon their work of making glass models of animals, chiefly marine invertebrates, which were sold to museums over the world, and devote themselves entirely to the construction of plants. They were, however, finally persuaded, on their own terms, to give their entire time to this work, and, by the last contract executed in Dresden in 1890, a certain number of models are to be sent to this country twice a year, for ten years. An American garden around their house supplies them with North American plants, while, from the royal garden of Pilnitz near by, they secure specimens of the vegetation of Central and South America. Leopold, the son, visited this country in 1892, and, in his travels to Jamaica and over our West, he prepared himself, by studies in color and collection of material, for the production of over 200 species.

Certain secrets are in their possession, such as the use of color, the preparation of the more fusible kinds of glass, and a peculiar method of annealing. The process is not, in any sense of the term, glass-blowing. Dr. Goodale, who alone has been permitted to see the artists at work in their studio, was astonished at the rapidity and deftness with which they accomplished their wonderful results. They each average 50 plants a year, and, when the amount of labor, and the fineness of detail are considered, this is truly marvellous. Already 450 large and 1800 small models are on exhibition here, dis-

played in plate-glass cases in well-lighted rooms. What I wish to call especial attention to in this paper is, not the economic or aesthetic side of these models, but their botanical accuracy.[1]

Has the general public, has even the scientific student any idea that the glass flowers in the Blaschka collection possess an accuracy of detail that is positively startling? The eye is at first attracted by the great beauty of the flowers, as they lie on their white cards in the glass cases, and, on a closer examination, we are more and more surprised and delighted to find nature so accurately followed in all those details that can be seen by the unaided eye. But surely the lens must reveal inaccuracies which are otherwise invisible. It seemed to me impossible that the artists could have produced a plant covered, perhaps, with minute flowers, with such exactness that any flower taken at random should follow the specific characters of that particular species, as if we had the natural plant before us. The general end would be subserved if the aesthetic features were kept in view, and a reasonable care in the finer points were shown. Even then the work of the artists could not be too highly commended. But, surely, nobody could expect to find the right number of stamens in every flower, the proper degree of pubescence on the stem, and such other characters as only a microscopic examination would reveal. It was to test this question of botanical accuracy in those finer details that I made a critical study of a number of specimens taken at random from various orders. I compared each plant with my own herbarium specimens, relying more on the natural plant than on the printed characters. In this way I could see many fine points which are not described in the books.

The first specimen was *Aster Novæ-Angliæ* L., var. *roseus* DC. The upper half of the plant is represented, besides four magnified portions of the flower-head. The hirsute stem and the numerous auriculate finely pubescent leaves are perfectly represented, but, when one examines the inflorescence, the wonder deepens. As far as the delicate fingers of the artists, guided by a most accurate knowledge of the complex structure of this flower-head could accomplish it, everything is present. The linear recurved scales of the involucre, the

[1] For further information on the inception of this collection, see the article on the Blaschka Glass Flower Collection in the Harvard Graduates' Magazine for July, 1893.

roseate rays showing even the styles (for in Aster the ray-flowers are fertile), the discoid or central flowers, are all clearly depicted. This is true not merely in a single head, but in them all, without exception. The young buds, showing only the involucral scales, are very natural, while in the older buds the rays are erect, not having fully expanded, and all the discoid flowers show only their small rounded tops. In the fully developed heads the central flowers have opened, and the syngenesious stamens show their yellow anthers in the outer row or rows, as one head is older than another. Herein the artists have shown their wonderful skill. Their models are the living plants, and every flower has its separate pattern, no two being exactly alike. They are not all cast in one mould.

In the older heads the central flowers have all opened, the stamens cover the surface, and the rays are incurved with withering tips. In this species, as well as in all the others, the magnified portions have been done with the greatest accuracy, and afford a fine object lesson. An involucral scale shows the glandular pubescence, and a floret, enlarged thirty times shows the hairy akene with the pappus of capillary bristles upwardly barbed, while the tips of the five-lobed corolla have their peculiar rosy hue, so different from that of the rest of the floret. The stamens pointed at the top and the forked style are all there too. The systematic analysis of this Aster can easily be made from the model, so perfect is its construction.

I have thought it best to give these details in the case of one plant, so difficult to produce, but, in the case of the others, which were as carefully studied, to give the important features of only a few. I found the same fidelity in matters of the slightest detail. Sixteen species I examined by careful comparison, besides making a more general observation of a large number. I sought faithfully to find some error, something systematically wrong. A fair criticism should disclose whatever faults may exist, but I failed to find such faults, with the exception of a very few cases, where some feature was not quite like that of the type species. The artists drew largely for their material from cultivated specimens of our plants, and in the few cases where some slight detail is not quite typical of the species, I am confident that this is owing to the fact that variation is apt to occur in plants under culti-

vation. There is such rigid observance of the very minutest features in every other case that we can be absolutely sure that every model is an exact copy of the fresh specimen which the artists had in hand.

Steironema ciliatum L. exhibited most beautifully all the fine characteristics of that gamopetalous species. The cuspidate-pointed, erose-denticulate corolla lobes, with stamens opposite these lobes, give the flowers a most natural appearance. Here, too, the varying age of the flowers is shown, from the tightly-closed bud to developing fruit. The ciliate petioles, a character to which the plant owes its specific name, are faithfully produced. The magnified stamen shows the fine granules on the filament, as they occur in the living plant.

In the case of *Aralia spinosa* L., the building up of the complex inflorescence with its multitudinous minute flowers, is almost past belief. In this cluster, with its flowers so small that their structure can be seen only with a lens, while many of its buds are so minute as to be indistinguishable to the naked eye, I counted, of buds, blossoms and developing fruit, from 2,500 to 3,000. And yet every flower has its five petals, and five alternating stamens with long filaments. I sought to find on the under part of the cluster some flowers perhaps less carefully done, as being practically out of sight, but they were all equal in their perfection. The immense compound leaf shows the spines scattered irregularly along the stalk and midribs. The pale under surface of the leaflets is quite invisible owing to the position of the leaf on the card. Were every specimen in the collection to be inverted, the same accurate work would be seen.

It is needless to multiply cases. It would be a continued record of what has already been described. Such wonderful work as this could have been done only by those whose love for nature and nature's works was deep. This love, combined with a master's skill, has produced a result never before equalled. How can we sufficiently admire the conscience that will not allow the slightest detail to be overlooked where this omission might most naturally be expected, and the patience that makes the last flower as accurate as the first, though there be hundreds on a single plant.

Each flower of our common milkweed, *Asclepias Cornuti* Decsne., shows the interesting features of this genus. I counted forty-four flowers, and thirty buds, and in each case there

were the five hoods with their incurved horns surrounding the stigma. No two leaves were alike, but they exhibited the variation observable in this species.

The delicate corollas of *Teucrium Canadense* L., the wood sage, show their four exserted stamens. The blue flowers of *Polemonium cæruleum* L. are rendered wonderfully perfect by the five stamens, with hairy base, and fine 3-lobed style, while *Euphorbia corollata* L., in its singular involucre, contains the sterile flowers, each consisting of but a single stamen, and, in many cases, the fertile flower protrudes with its 3-forked style, each fork showing under the lens that it is cleft at the end. Here again the natural character is shown in the fact that the fertile flower is in various degrees of development; in some cases not yet visible, and in others with its ovary drooping over the side of the involucre. The lens is necessary to detect all this. I would call special attention to the inflorescence of *Alisma Plantago* L., which is wonderfully accurate, and also to *Hordeum jubatum* L., a most successful attempt to copy the long-awned spike of this grass. The magnified portions show the structure of the flowers.

But enough has been said to show the marvellous care and accuracy of the artists in all their work. Every plant tells the same story of nature closely followed out, and I am glad to bear my testimony to the almost magical work of Leopold and Rudolph Blaschka.

Cambridge, Mass.

The influence of mechanical resistance on the development and life-period of cells.

FREDERICK C. NEWCOMBE.

Introduction.

The question as to what actively growing plant tissues will do when their growth is checked by external mechanical resistance had received but small notice in literature till the appearance of Pfeffer's[1] latest published work. Some years ago, however, De Vries,[2] by winding stems with twine, found that the cambium gave rise to fewer cells under this resistance and that the wood elements expanded more slowly. Krabbe[3] by applying a graduated pressure to the trunks of trees, found the cambium cells uninfluenced either in size of lumen or in thickness of wall both when the cambium was forming new cells under various pressures and when the formation of new cells was entirely stopped by sufficiently increasing the resistance. This author confirmed De Vries' observation stated above, that the time between the formation of a wood element and its definitive condition was lengthened by increasing the pressure under which it grew. Wortmann[4] placed bandages of twine about the stems of seedlings of Phaseolus multiflorus and two other seedlings and found within a few days that the subepidermal collenchyma was abnormally thickened. This thickening he used to strengthen his theory of growth, believing that cell-walls grew thicker than normally when they could not reach their normal surface extension.

Pfeffer in the work referred to enclosed the root-tips of several species of seedlings, the stems of a few species, the growing points of Chara and Nitella, and the filaments of Spirogyra in gypsum casts. From the behavior of these preparations he deduces these results:

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[1] Pfeffer, Druck und Arbeitsleistung. Abhandlungen der könig. säch. Gesells. der Wissenschaft **20:** —. 1893.

[2] De Vries, De l'influence de la pression du liber sur la structure des couches ligneuses annuelles. Extrait des Archives Neerlandaises 1876. Also, Vorläufige Mittheilung, Flora —: 97–102. 1875.

[3] Krabbe, Ueber das Wachsthum des Verdickungsringes und der jungen Holzzellen in seiner Abhängigkeit von Druckwirkungen. Berlin. 1884.

[4] Wortmann, Beiträge zur Physiologie des Wachsthums. Bot. Zeit. **47:** 286. 1889.

1. Embryonal tissue preserves for a long period in a gypsum cast its capability for growth.

2. In gypsum casts the differentiation of tissue advances nearer the growing point than normally, thus necessarily shortening the zone capable of elongation.

3. The cells of the embryonal tissue do not divide when their extension is prevented, but the cells of the tissue adjacent to the embryonal tissue do, in some plants at least, divide at a size somewhat less than their normal.

The following pages contain further observations on the questions already stated and besides show the effect of external mechanical resistance on

1. The duration of the growing period of cells;
2. The duration of the life period of cells;
3. The permanent condition assumed by cells.

This work was begun in Leipzig under the direction of Professor Pfeffer and completed in Michigan University since the author's return.

Methods.

The method used to arrest growth by mechanical means has been the employment of gypsum casts.[5] An organ to be encased had fitted about it an envelope of stiff paper closed at the bottom by a divided cork, by molding clay, or by cotton wool. A thick mixture of gypsum and water was stirred up and poured into the envelope and there allowed to harden. Two precautions are necessary to the securing of good results: the cast must have a diameter several to many times that of the organ encased to prevent springing by the energy of turgor;[6] the cast must have a length of three or more centimeters, since experience has shown that disturbing factors come into play in proximity to the limits of the gypsum envelope.

At the close of the experiment, the preparation was cut from the plant, the enclosed organ removed from the cast and subjected to microscopical examination. To free the organ from the gypsum, two longitudinal trenches were cut with a

[5] Pfeffer has used this method in researches for some time and has described it in *Berichte d. k. saechs. Gesellsch. d. Wiss.*, Dec. 1892: Ueber Anwendung des Gipsverbandes für pflanzen-physiologische Studien.

[6] Krabbe found the outward pressure of turgor under a ligature to reach fifteen atmospheres in the stems of dicotyledonous trees (l. c.), and Pfeffer found the pressure given by the roots of seedlings in gypsum casts to reach in some cases twelve atmospheres, while in the stems of some seedlings the pressure was six and one-half atmospheres. (Druck u. Arbeitsleistung, p. 188.)

knife or saw from opposite sides of the cast down nearly to the plant organ enclosed. The halves were then easily broken apart without injury to the plant tissue.

The cells were regarded as living or dead according as plasmolysis was present or absent after placing sections in a ten per cent. solution of potassium nitrate.

The following plants were used in the experimentation:

Allium cepa L.,
Althæa tauriensis DC.,
Archangelica sativa Mill.,
Caltha palustris L.,
Cucurbita pepo L.,
Dahlia variabilis W.,
Equisetum limosum L.,
Eryngium planum L.,
Forsythia viridissima Lindb.,
Helianthus tuberosus L.,
Juglans nigra L.,
Juncus effusus L.,
Lamium garganicum L.,
Ligusticum Leguari,
Melianthus major L.,
Myrrhis odorata Scop.,
Phaseolus multiflorus Lam.,
Phytolacca dioica L.,
Pterocarya fraxinifolia Nutt.,
Ricinus communis L.,
Sambucus nigra L.,
Triticum repens L.,
Urtica dioica L.,
Vicia faba L.,
Zea mais L.

Experiments and discussion.

Effect of mechanical resistance on the growth and preservation of meristematic tissue.

In operating upon the growing points of the roots and stems of several species of seedlings, Pfeffer[7] found that within a gypsum cast which prevented all extension of tissue, the ability for growth was retained for many weeks. In the cases tested, growth was immediately renewed on removal of the cast. Here, then, with all the conditions of growth favorable, except the space in which to extend, the primary meristem retains its functional capability as it does when obliged to rest by low temperature or by insufficient moisture. Pfeffer found also the growing tips of Chara and Nitella living after being three months in gypsum.

My own experiments have shown that intercalary meristem and cambium as well as growing points retain their functional capability for long periods when their growth is prevented by similar gypsum casts. In Juncus, as is well known, the meristem for the growth of the aerial stems is at the place where such stems grow off from the rhizome. Casts were placed around the bases of many stems and about the rhizomes so as to include the zone of meristem. Some of these preparations were examined five weeks afterward, some after eleven weeks.

[7] Pfeffer: l. c., p. 124.

The cells of the meristematic zone were in all cases living and normal in appearance at both periods of examination.

The growth of the leaves of Allium cepa is also intercalary; the meristem is at the leaf-bases. Several experiments were made on this plant by including within a cast the upper part of the bulb and the young leaves which had started from it. The cast was then fastened by bandages to the bulb so that bulb and cast could not separate, yet so that the roots could grow out freely. The preparations were examined, some at the end of two weeks, some after thirty-one days. The results were the same in all cases. The meristem remained alive, and growth was resumed upon removal of the casts.

The effect on the cambium of arresting its growth by external resistance has been determined by enclosing within gypsum casts the stems of many plants both herbaceous and woody. To prevent by this method all extension or growth in the cells within is impossible, since the presence of intercellular spaces always affords some room, and the resistance of vessels is not sufficient to withstand the force of turgor of the thin-walled cells. Thus, though the cambium has not been held in these experiments, and could not be, in a state of absolute rest as regards growth, its activity in this direction has been, as will be seen, very slight. The amount of growth from the cambium in such circumstances must depend entirely on the room it can make for itself, and differs therefore in different species of plants, and differs also in the same species, since the size of the intercellular spaces and the turgor of a tissue will differ with age. In young stems of many plants the primary meristem of the fibrovascular bundles has been preserved in an almost quiescent condition for several weeks. Rarer examples of long continued rest have been furnished by Lamium garganicum, Vicia faba and Dahlia variabilis in which so slight was the development within the casts that for 40, 50 and 120 days respectively the formation of the interfascicular cambium was prevented, though it was formed immediately below and above the limits of the casts, and the growth of the plants as a whole continued. Yet notwithstanding this long rest the primary meristem was apparently and undoubtedly capable of farther active growth.

In cases where the casts were applied after the cambium zone was completed, there are many individuals, representing several species, bearing testimony to the long preservation

of this meristematic tissue when its growth is mechanically checked. In none of these cases were the experiments continued till the death of the cambium, and hence the duration of its vitality, when its growth is mechanically prevented, is still undetermined. Pfeffer, in the work mentioned, states that the root-tips of Vicia faba in casts remained alive for five weeks, but that at the end of ten weeks had begun to die. The cambium certainly lives longer under similar conditions. Cucurbita pepo with considerable growth of stem outside the cast and very few changes within the cast has preserved its cambium for sixty-six days. Eryngium planum and Ligusticum Leguari about whose stems casts were placed at the time the cambium ring was completed, grew well afterward, forming outside the casts normally thick stems, and at the time the plants were taken for examination had produced seeds; the cambium was thus preserved in these species for seventy days. Young plants of Vicia faba grew after the second or third epicotyledonary internode had been encased in gypsum to a size and development equalling normal plants and had seeds partially formed when the plants were cut for examination 116 days after placing in gypsum. Dahlia variabilis does not grow very well when a cast is put around a very young stem. Several individuals however added half a meter to their height and were still growing and had healthy looking cambium within the cast 138 days after the beginning of the experiment. Pterocarya fraxinifolia, Juglans nigra and Forsythia viridissima formed branches in most cases as well developed as normal ones, though the same branches when young had had gypsum laid around them, and within the cast formed but few seconday elements, Forsythia in one case forming but four or five in a radial row. This experiment was continued for seventy days, at the end of which period the cambium appeared normal. In similar conditions and with similar results Sambucus nigra was grown for ninety-six days, Ricinus communis for 100 days and Phytolacca dioica for 197 days. In the last named plant, in one stem, there had been formed within the cast five or six cambial derivatives in a radial row after the experiment was begun, while above and below the cast thirty to thirty-five such cells had been formed.

It is to be understood that in all these cases the stems had increased greatly in diameter beyond that of the part within

the cast; as extreme examples may be mentioned Vicia, Dahlia, Ricinus and Pterocarya where the diameter outside the cast was often to that within as two to one.

Effect of mechanical resistance on the duration of the period of development of cells.

1. *On the zone of elongation in roots and stems.*—When root-tips or stem-tips of seedlings are fixed in a gypsum cast, the power of elongation becomes day by day reduced to narrower limits, so that when the growing point is released from its confining envelope, subsequent growth shows that the proximal limit of elongation is nearer the apex of the organ than formerly. Pfeffer[8] demonstrated this in several species. In the primary root of Vicia faba, for instance, where normally the elongating zone is about 10^{mm}, he found this zone reduced to 5^{mm} or 6^{mm} after two or three days in a cast. My own measurements have shown that in a normally growing primary root of Vicia faba at a temperature of 20°, the fourth millimeter from the apex of the root will in twelve hours have passed out of the segment of elongation. But Pfeffer's root-tips showed elongation in the fifth or sixth millimeter after two or three days in casts. Thus it is evident that the effect of the casts was to retard the passage of the elongating segment into permanent tissue.

Analogous with this result is that obtained in my experiments with Juncus and Lamium, where several very short shoots of the former in which tissues were undifferentiated were kept alive for eleven weeks in casts, and then showed no differentiation; and in the latter the stem just behind the terminal bud was, in one case for twenty-five days, in another for forty-five days, by the same means kept from developing farther, except that two or three cells in the primary bundles slightly thickened their membranes. Meanwhile the stems had grown above the casts and the tissues had become much better developed than within the casts.

2. *On differentiation in fundamental parenchyma.*—Not only in the tissue adjoining the meristem of growing points will development proceed more slowly when a mechanical resistance prevents expansion, but in those later changes which in many plants the fundamental tissue undergoes will the same result follow. In Zea mais the cells which normally form the

[8] Pfeffer, l. c., pp. 120 and 149.

sclerenchyma sheaths have, by the employment of casts around the stem, been kept thin-walled for thirty-seven days, in Caltha palustris for fifty-two days, though these cells remained alive and in the same stems above and below the casts passed into their thick-walled condition.

Other plants in which the outer zone of pith-cells normally becomes thick-walled have served still better to illustrate this principle. Numerous examples of Vicia faba have shown that the outer pith-cells begin to thicken their membranes two or three weeks after their internode is fully elongated. If, however, a cast is laid around a very young internode, the thickening of the membranes of the pith-cells will be delayed for weeks after it has begun in the internodes of the same stem above and below the cast. Thus in a stem that had grown to the height of ten internodes, whose third internode above the cotyledons had been encased in gypsum before elongation was complete, the subsequent period of growth being thirty-two days, the pith-cells beyond the limits of the cast were becoming thick-walled, while within the cast they retained their thin-walled condition. Other plants of the same species similarly treated but allowed to grow twelve days longer, at which time they had added to their height and begun to blossom, showed within the limits of the casts the outer pith-cells just beginning to thicken their membranes. Similar preparations, but twelve days older, and consequently of stronger development, showed the outer pith-cells with membranes thickened, but still thinner than in normal parts of the stems. Urtica dioica, twenty-three days after two or three young internodes were enclosed in a cast, had above the casts thick-walled pith-cells bounding the inner ends of the bundles, but only thin-walled cells in similar positions within the casts. Other stems growing for forty days after casts were applied in like manner, showed within the casts the outer pith-cells with thickening membranes. In Dahlia variabilis the outer cells of the pith have by means of casts been kept thin-walled ten weeks later than in neighboring normal parts of the same stems. Still older preparations have shown however that if growth in the plant as a whole continues these cells will eventually become thick-walled. Archangelica sativa and Myrrhis odorata form a broad zone of mechanical pith which bounds primary and secondary xylem internally. Segments of stems of these two species have presented within casts the

pith entirely thin-walled, when above and below the casts the zone of fully thickened pith-cells has been six cells in radial width.

If we turn now to woody plants we shall find the same results presenting themselves. Several shoots of Melianthus major had casts placed around them so as to leave only the terminal bud exposed above. Up to the time when three internodes had been subsequently developed there were no thick-walled cells in the pith of the segment in cast, but above and below the cast there was a broad band of thick-walled lignified pith. In shoots similarly prepared but of farther development above the casts, there was always an evident thickening of the outer pith-cells within the limits of the casts, this thickening progressing in the older preparations till it approached that of like cells outside the confined area. The same general results were obtained by similar experiments with Forsythia viridissima and Pterocarya fraxinifolia.

Many plants which have collenchyma in the cortex of the young stem do not, as is well known, increase the amount of this tissue as growth proceeds, while others with increasing age in an internode show the collenchyma increasing in number of cells and thickness of membrane. Sambucus nigra belongs to the latter class. When in the spring very young shoots have some of their internodes enclosed in gypsum and are allowed to grow subsequently, the increase of the collenchyma is found to be more tardy within the casts than outside of them, though the thickening of cell-walls is still slowly progressive within the casts.

In the young stems of Archangelica sativa and Myrrhis odorata the collenchyma strands of the future exist in a very thin-walled condition. By laying gypsum around segments of such young stems, the strands referred to have been in Archangelica for twenty days, in Myrrhis for twenty-seven days, kept in their thin-walled condition, while above and below the limits of the casts the strands in the same time formed very thick-walled collenchyma. How much longer these cells would have remained thin-walled within the cast was not determined by other experiments; but that they were still capable of growth there can be no doubt, for they were at the time of examination well provided with protoplasm.

The fact that the sclerenchyma of the fundamental tissue develops more slowly against mechanical resistance has been

mentioned for Caltha palustris and Zea mais. The same is true of the only other plant in which the question was studied, viz., Cucurbita pepo. In this plant after elongation of the internodes the innermost cortical cells thicken into a heavy zone of sclerenchyma. In internodes confined in casts this zone has been delayed in development into sclerenchyma for several weeks, though it could there be identified as a band of thin-walled cells. Older preparations have shown this band becoming slowly thick-walled, the progress continuing after the full thickness of wall had been obtained in parts above and below the cast; though in the oldest preparation examined these cells had not become so thick as in normal parts of the same stem.

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[*To be continued.*]

BRIEFER ARTICLES.

Compass Plants.—I was among the first to be interested in the peculiar twisting of the leaves of the *Silphium laciniatum*, and my paper published in 1865, in the "Proceedings of the Academy of Natural Sciences of Philadelphia," shows how closely the curious plant attracted me. There were some lingering doubts about the "polarity" of the leaves, till one day, when in St. Louis, my good friend Dr. Engelmann, took me to a waste lot in that city, where *Lactuca Scariola* had just secured a foothold. He was a strong believer in polarity, and I gave up. I have, however, continued for a quarter of a century to look for additional facts. It is surprising, if we look closely, how many plants we shall find twisting as Mr. Foerste describes the leaves of some doing (this journal, *ante*, p. 35). Possibly the best of all to study are *Gaura parviflora*, and *Chrysopsis villosa*. With a prepossession in favor of "polarity" I used to think I saw in these good evidence thereof. Continuous and careful watching proved I was wrong. I have long had to abandon this hypothesis in all except the Silphium, as a single plant in my garden is not a fair test. Not seeing them in any quantity I have to be simply an agnostic in regard to its "tendency to evade the direct rays;" and many other suggestive explanations I have also had to abandon.

A few years ago, I found myself at Gettysburg a day ahead of time. Of course it was devoted to botany. *Lactuca Scariola* had got there before me, and was in considerable quantity in some portions of that sacred ground. I walked and sat among them a couple of hours, determined it should give up to me the secret of its upturned leaves. With some strong shoots of species of Solidago before me, I was reminded of a strong but cordial controversy by letter, extending over some time, that I had had in the past with Dr. Asa Gray, I affirming that the leaves of plants do not originate at the nodes from which they appear to spring—a point, by the way, I can more strongly defend to-day. It could be easily seen, by these Solidago stems, that the leaf blades had twisted pentamerously around the stems from some indefinite point below, the edges of each leaf *overlapping*, just as paper overlaps when the confectioner twists a piece of paper into a "cornucopia" bag to hold the sweetmeats; and that-leaf blade, as we finally come to understand the term, is the last crowning act of the spiral growth. With this key it did not take long to open the Lactuca mystery. The whole of my quarter of a century of search seemed rewarded. I have since used the key to the mystery in other plants, and the treasure-box opens as easily. It is the same answer all round. ***The twist is the result of a somewhat prolonged effort of spiral growth,*** and of no physiological value whatever.

I was for a time puzzled by a certain uniformity in the direction of the leaves—not by any means always with the edges north and south. Especially was I puzzled in noting that the first opening of a flower of *Helianthus mollis* was to the south-east. But here came in what I think is a point I have established, that growth is rhythmic and not continuous, and that growths that start together are likely to rest together. A quantity of seeds, starting at the same time under the same day's warm sun, would naturally have similar resting phases. Seeds starting at other times, or under some peculiar conditions of vital power, would disarrange total uniformity in results.—THOMAS MEEHAN, *Germantown, Philadelphia.*

An additional poisonous plant.—D. T. MacDougal (Bulletin 9, part 1, Jan. 16, 1894; Minnesota Botanical Studies) gives in a convenient reference list the plants of Minnesota known to be poisonous, producing the symptoms called by physicians *dermatitis venenata*, or rhus poisoning. He mentions two species of Ranunculus in his enumeration, *R. septentrionalis* Poir. and *R. sceleratus* Linn. *Ranunculus acris* L. must be added to the list of known or reputed skin irritants, as the following account will show. This species, preserved in alcohol for over a year, was distributed to a university class for study, and in doing this the fingers and hands were frequently immersed in the alcohol of an olive-green color. A day or two afterwards an intense itching sensation was experienced. The softer skin between the fingers became red and covered with minute watery vesicles, or pustules, and after the inflammation had disappeared, the skin of the fingers began to crack, as if they were chapped. These symptoms were exactly similar, in my case, to the effects produced by contact with the poison ivy, Rhus toxicodendron. The watery acrid juice, so universal in the Ranunculads (dissipated in many forms in drying), had been extracted from the plants, and evaporating on the surface of the hands left behind the precipitated active irritating principle.

The wide distribution of the poison sumachs has been accomplished by the carrying of the drupes in the stomachs of birds. An instructive fact, which has come to light recently through the examination of crow stomachs, is the discovery that the fruits of the poison sumach, Rhus venenata, and poison ivy, Rhus toxicodendron, are eaten in large numbers by the crow. W. B. Barrows has in one case recorded that 153 seeds of the poison ivy were found in a single stomach. A single pound of dried excrement taken from a roost in the National Cemetery at Arlington, contained by actual count 1041 seeds of Rhus toxicodendron and 341 seeds of Rhus venenata, in addition to 3271 seeds of other sumachs, 95 seeds of Juniperus Virginiana, 10 seeds of Cornus florida and 6 seeds of Nyssa sylvatica.—JOHN W. HARSHBERGER, *University of Pennsylvania, Philadelphia.*

EDITORIAL.

THERE ARE many advantages in being in the current of the world's activity. Botany is restrained in its development, and shorn of just recognition, because its representatives are still largely willing to paddle about in quiet bayous, content with the richness of botanical materials and the opportunity of uninterruptedly studying them, without giving a thought to the great interests involved in the surging, pushing mass of commerce and daily traffic which pass near by, accompanied by the noise of enginery and the display of competition. A well known botanist, who has occupied a public position for many years, explained to the writer some time ago that he preferred to go without much needed facilities in the way of books, room and assistance rather than make a request for them or do anything that would attract the attention of the politicians, who would probably abolish the office or bring about some calamity if they remembered that he was in existance. This feeling is a survival from the old days when the botanist was a scholarly recluse, and neither he nor any one else dreamed that his knowledge could have a cash value. Botany was taught then, and is often taught now, as Arabic or quarternions are taught, not because it would help one to gain a livelihood, but for its disciplinary and educational value.

A MIGHTY CHANGE has overtaken the spirit of the botanist in recent years. He has emerged from his herbarium den, and looks at the world with a clear eye instead of constantly peering through a magnifier at a bit of unrecognizable vegetation; he is occasionally seen in cultivated fields, instead of prowling through thickets and out of the way marshes; he speaks like a man who is watching for an opportunity to develop a new industry, and no longer acts as if he fully believed that industries and botanical science are unrelated and incompatible.

But the transformation is not complete, in fact it is only so far along as to make its tendencies clearly recognizable. There are still good botanists who will not admit that there is any actual change. They are content that the study of the food of plants should be carried on by chemists, the investigation of the laws of breeding and practical treatment of diseases by horticulturists, the relation of plants to heat, light and electricity by physicists, the study of bacteria by pathologists, the examination of fossil plants by geologists, and so on. In repudiating the connection of these and other lines of investigation

with the science of botany, especially where a practical or commercial end is in view, the botanist loses the advantage derived from popular approval. It is more difficult to obtain ten dollars to equip a laboratory for vegetable physiology than a thousand dollars for a labortory of chemistry, because Baron von Liebig and others long ago fully convinced the popular mind that a knowledge of chemistry was essential to an intelligent pursuance of most of the arts and industries. And so thoroughly was this done that every man, even to the present day, although he may not know the names of the elements, associates chemistry with the indispensable in education, while he has hazy, if any, notions about vegetable physiology or its application. A Liebig is needed in botany.

IT IS A SOUND principle in advertising that having an article of genuine worth and general utility the profit from it will be in proportion to the extent to which it is made known. Botany, both as a fundamental and as an applied science, is in some respects like a commercial article. The better its merits are known the greater its income will be in the way of money for teaching equipment, for laboratories, for research, for salaries, for assistance, the more and varied the demand for botanists, in short the greater activity and the greater possibilities.

The progress already made toward creating a need for botanists in the commercial world is considerable, and is every year increasing the demand for well trained men. At present the most promising field is vegetable pathology. In this line the action of the orange growers of Florida is significant. They have endorsed and substantially aided the Sub-Tropical Laboratory at Eustis, and recently have formed a stock company to send a botanist around the world to collect and study citrus and other sub-tropical fruits, to observe their diseases, and in every way possible to make available whatever knowledge an able botanist can gather with practically unlimited resources. A method of caring for orchards and vineyards, likely to be introduced by some enterprising community, is the employment of a pathologist to take charge of the health of the plants, spray them at suitable intervals, and to be on guard against parasites. There are at present many ways in which botanical knowledge can be made to yield a livelihood beside teaching. The greater and more diversified the demand for men trained in botany becomes the better it will be for all branches of the science, and for all its devotees.

CURRENT LITERATURE.

A Californian Manual.[1]

It has long been recognized that the flora of the Pacific coast is a wonderfully rich one, and that detailed exploration is almost daily bringing to light new plant forms. It has also been a matter of regret that no handy manual brought even an outline knowledge of this flora within reach of those to whom botanical libraries are not accessible. The " Botany of California," in two large volumes, is a monument to the generosity of certain citizens of that state, and it formed a fitting foundation for study; but it is both costly and hard to get, and is now far from expressing our knowledge. Keen collectors have been plentiful upon the Pacific coast, and it seemed hardly worth while to prepare a manual which must of necessity be incomplete before it could get through the press. The most indefatigable student of this flora has been Professor Greene, as his numerous publications will testify. His "Flora Franciscana," appearing in parts, is already well known, and now he has presented a manual of the same region for the benefit of the schools and colleges, and all students desiring "to make some beginnings in the systematic botany of middle western California." But nine counties are included, and ninety natural orders of flowering plants, the sedges and grasses being notable omissions, and the indications are that a complete manual of the whole state would be a huge affair. The author's purpose is most commendable, and we do not doubt that the book will be a great boon to beginning students in the "Bay-Region." Besides, no botanist has so intimate a knowledge of the flora of the region presented, and hence no one is so well fitted to act as guide.

Our only criticism is from the standpoint of the professional botanist. Professor Greene says that "there is much that is new for the bibliographer and the nomenclator within these pages;" also that "this feature will not in the least affect the usefulness of the manual as a book for beginners;" but that "the inconvenience will be realized only by the experienced botanist." We heartily agree with all three of these propositions, especially the first and last, for there is very much that is new for the bibliographer, and it is the most inconvenient book for the experienced botanist that it has been our fortune to examine. Knowing how thoroughly the author appreciates

[1] GREENE, EDWARD LEE.—Manual of the Botany of the Region of San Francisco Bay. 8vo. pp. xiii, 328. San Francisco, 1894.

the value of frank criticism, of which he has become so distinguished an exponent, we venture to confess ourselves discouraged by this book. It gives one so constantly the impression of straining after changes, that we find it hard to rid ourselves of the impression. One expects a reasonable amount of this in generic and specific combinations, for we can hardly move without jostling these; but when it attacks ordinal names, sequence, everything, it makes one wonder how very completely all other botanists have gone astray. Possibly this impression may wear off. The very great inconvenience of the book to the professional botanist is the entire omission of synonyms. It can hardly be expected that a botanist in these days can carry in his head all the permutations of nomenclature, for it would be as impossible and about as profitable as to remember the daily weather reports; and it also cannot be expected that he will have time to look up the synonymy in various publications. This seems to us a more serious defect than the omission of an index. Our feeling of discouragement, however, chiefly arises while contemplating the generic names and their reference. It seems to us that if Galen, and Theophrastus, and Vergil, and Pliny, *et id omne genus*, are to be consulted for generic names, bibliography at once becomes an impossibility and systematic botany the common dumping ground for all literature. There is no reason why the wonderful Semitic libraries should not add their clay volumes to the confusion, for they indicate and name many a plant that has been clearly identified. We are very glad that the author has said that "no botanist will be obliged to adopt the nomenclature of the Manual of Bay-Region Botany," and we sincerely hope that they will follow this wise caution. Of course, he means to say that if we do not like it we can say so, a privilege of which we are glad to avail ourselves, and we therefore enter our protest against this use of pre-Linnæan names. We ourselves have participated in revolutions of nomenclature in the interest of peace, and not that one revolution may simply be the prelude to another. We have thought that one thorough resurrection of names since systematic botany became a science might be necessary to their permanent burial decently and in order, but we do not expect to be parties to a perennial resurrection. Highly as we esteem Professor Greene we cannot just now follow him any further in this ghoulish business, and we trust that he will understand that we have deserted him, not for his own sake, but on account of the company he keeps.

Revision of Guttiferæ.[1]

This latest volume of a series of famous monographs, which form a continuation of the *Prodromus*, is the last one to bear the name of Alphonse De Candolle. In a prefatory note the son, Casimir, promises that the third generation will continue the work on the same plan. The volume is also interesting because M. Vesque has made large use of minute anatomical characters, including them everywhere in his descriptions. In the preface the author discusses the value of such characters and emphasizes the importance of their increasing use in recent systematic work. The limitation of the family is along the old lines, the *Hypericaceæ* and certain genera of *Ternstroemiaceæ*, which are included by Engler in *Die Natürlichen Pflanzenfamilien*, being excluded. The *Hypericaceæ* are not excluded on the basis of the distribution of resiniferous canals, as suggested by Van Tieghem, but are regarded as entirely distinct on many grounds, strikingly so in minute characters. For instance, the hairs, the stomata, the oxalate crystals, all oppose such union. The stomata of *Guttiferæ* are constantly of the rubiaceous type, that is, with two accessory cells parallel with the cleft; while those of *Hypericaceæ* are as constantly of the cruciferous type. Such work is to be expected of M. Vesque, who sees in minute anatomical structures the same principles of evolution developed, indicating genetic relationships, that we have been accustomed to apply only in gross structures. Under each species the two sets of characters are distinctly separated, his "epharmosis" giving a compact account of the histological peculiarities. One cannot but feel amazement at the immense amount of work such treatment involves. This great tropical family, of which the large tribe *Clusieæ* is exclusively American, is represented in this monograph by 495 species, forty of which bear the name of M. Vesque as author. The three large genera are *Garcinia* of tropical Asia and Africa, with 186 species; *Clusia*, of tropical America, with ninety-six species; and *Calophyllum*, of the tropics in general, with sixty-four species.

A curious and quite effective method of presentation is used in the discussion as to the value of "epharmonic" characters, in relation to the large stress put upon the development of the hypoderma. Two botanists, A and B, are represented as debating the question and taking opposite views. Naturally A, who adopts the value of "epharmonic" characters, easily prevails over the opposing B.

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[1] Vesque, J.—Monographiæ Phanerogamarum, etc., Alphonse and Casimir DeCandolle editors, Vol. VIII, Guttiferæ. 8vo. pp. 670. Paris: G. Masson, Dec. 1893.

The biology of ferns.[1]

We are somewhat puzzled to discover from what point of view we should criticise this book. To classify it is difficult. It is strictly neither a student's handbook nor a treatise, but something of a combination of these. Nor is it sufficiently either one or the other to demonstrate clearly its *raison d'être*. We have asked ourselves how we could use it; and the answer seems to be that it will be convenient to have the figures and the facts it contains in one book instead of in several; to have some fresh illustrations, instead of those already familiar; and to have some concrete directions for collodion imbedding to supplement the general and comprehensive ones.

By this we do not mean to imply that the book is merely a compilation, for the author and his pupils have done a large amount of (in a sense) original work for it; yet there is not much in it that is really new. Nevertheless it has ample value to assure it a wide welcome in botanical laboratories.

The book hardly seems to justify its title, if we understand it; for it treats not of the biology of ferns (which, we take it, cannot be studied by the "collodion method"), but of the morphology and comparative anatomy of ferns. In chapter I of the first part, Professor Atkinson describes succinctly the development of the gametophyte and its sexual organs. He then devotes three chapters to the development, morphology and anatomy of the stem, root, and leaves of the sporophyte, and two to its sporangia. Chapter VII discusses the substitutionary growths from sporophytic and gametophytic budding, apogamy and apospory, while VIII is devoted to an account of the Ophioglosseæ. Part II treats of the technique of collodion imbedding and cutting, raising prothallia, etc., and contains directions for study. A bibliography follows, listing the most important papers, which, however, are not directly cited in the text.

All of the figures are original, most of them are excellent, and some are extraordinarily fine, notably 49, 139 and 140. A very few are distinctly bad, as 57, 58, 59. Fig. 131 is obscure and might do duty for a diagram of a cyclone. Figs. 19–23 and 25–27 were apparently left unfinished accidentally, lacking the outline of the cell walls. It would seem better to put the initials of the artist at one side than to incorporate them with the tissues themselves. Nor can we quite see the use of drawing a scale with each figure unless the figure and the scale are magnified to the same degree. In every case where magnification is

[1] ATKINSON, GEORGE F.—The study of the biology of ferns by the collodion method; for advanced and collegiate students. 8vo. pp. xii. 134. figs. 163. New York: Macmillan & Co. 1894.

shown it is stated in this form: "magnified 30 times more than the scale; scale=1^{mm}." Why not, "magnified x diameters;" or "scale .05^{mm}", drawing the latter with the same lenses as figure?

The book is gotten up in luxurious style, with heavy paper, wide margins and large type.

Minor Notices.

FOLLOWING his revision of our N. Am. species of Epilobium, Dr. William Trelease now presents, in his careful and thorough way, a revision of the small genera Gayophytum and Boisduvalia, six species of the former and four of the latter. Each species is illustrated by a plate showing general habit and dissections. These genera are peculiar to our western mountain region, and are also found in corresponding regions of S. America, but seem to be entirely wanting between. Dr. Trelease thinks that the indications are in favor of a former continuous distribution along the backbone of both North and South America. Gayophytum closely resembles the *paniculatum* group of Epilobium, and Boisduvalia was merged with Œnothera by Bentham & Hooker. The material is much confused in our herbaria, and this paper will do good service in helping us to proper identifications.

AN INTERESTING SYLLABUS of a course of lectures in biology has been issued by Dr. D. W. Dennis,[1] Professor of biology in Earlham College, (Richmond, Ind.). It is said of Oliver Wendell Holmes that he makes even an index attractive reading. A like ability is apparent in the present work, for the usual dryness of an outline of scientific lectures is relieved by the suggestive form of the topics, the numerous illustrative quotations and the range of the implied applications. The use of the word biology is also to be commended, as embracing the different fields of biologic science in a reasonably just proportion.

DR. J. W. MOLL describes[2] an oven for drying herbarium specimens rapidly. The apparatus is a double-walled oven with burners controlled by a thermostat. The chief novelty, however, consists in the use of corrugated paper, such as is used for packing bottles, between the sheets containing the plants. This hint may be good, even with the ordinary mode of drying.

A CONVENIENT host and habitat index of Australian fungi has been prepared by N. A. Cobb, government botanist of New South Wales. It is based upon M. C. Cooke's "Australian Fungi," and makes a pamphlet of 44 pages.

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[1] DENNIS, DAVID W.—Biology: syllabus of a course of ten lecture-studies. Earlham College: Department of University Extension, No. 3. [Richmond, Ind.]. 8vo. 20 pp., 10 cts.

[2] Separate from Botanisch Jaarboek **6**: 1–23, *pl. 1.* 1894.

NOTES AND NEWS.

THE APPENDIX of *Bulletin de l'Herbier Boissier* (Jan.) consists of a systematic conspectus of New Zealand Lichens, by Dr. J. Müller.

M. A. DE JACZEWSKI, in *Bull. l'Herb. Boiss.* (Feb.), reports the discovery of *Puccinia Peckiana* Howe in Switzerland, on Rubus saxatilis.

THOSE INTERESTED in the finer structure of the Desmideæ as applied to classification will find an important contribution to this subject on the pores of *Closterium* by Dr. J. Lütkemüller in the Œsterr. Botanische Zeitschrift 44: 11, 49. 1894.

IN THE February number of *Erythea*, Messrs. Ellis and Everhart describe twenty-nine new species of West American fungi; Mr. Davidson concludes his field-notes upon Calochortus; and Mr. Bioletti gives some interesting experiences in herbarium making.

NAWASCHIN has not only fully established the fact that the so-called "microspores" of Sphagnum described by Schimper are the spores of a fungus, *Tilletia Sphagni* Nawas., but has worked out the life history of the fungus. See Bull. de l' Acad. Imp. des Sci. St. Petersb. 13:394.

IN THE number of the *Journal de Botanique* for Jan. 16th M. Sauvageau continues his "biological notes" on the Potamogetons, P. crispus forming the subject of the present paper; and M. Bescherelle begins a series of descriptions of new mosses, the present fascicle being from Africa.

MR. A. P. MORGAN has continued his publication of the myxomycetes of the Miami Valley (Ohio) in Jour. Cin. Soc. Nat. Hist. 16: 127–156, presenting the two orders *Stemonitaceæ* and *Didymiaceæ*, and illustrating with two plates. Comatricha, Didymium, and Diderma each contains a new species.

MR. M. A. CARLETON, for several years assistant in the botanical department of the Agricultural College at Manhattan, Kansas, has recently been appointed an assistant in the Division of Vegetable Pathology at Washington, D. C. Mr. Carleton will have for his special work the rusts of cereals and other plants.

THE *Journal of Botany* (Feb.) contains an account, with plate, of the development of the stem and leaves of Physiotium giganteum (one of the liverworts with auricles or water-holding sacs), by Jesse Reeves, in which the development and structure of the auricle are described, and the stem found to grow by a two-sided apical cell.

THE PLANTS of Central Africa are being gradually brought to light and their geographical affinities made out. The latest results are those of Dr. J. W. Gregory, who gave an account of his exploration of Mount Kenia at the meeting on Jan. 15th of the Royal Geographical Society (London). He found on the higher elevations a mixed flora, having affinities with the European and Mediterranean floras on the one hand, and with the South African flora on the other.

In a paper on the spore-forming species of *Saccharomyces* (Amer. Naturalist, **27**: 685. 1893) one species was not mentioned, namely, the ginger-beer plant, *S. pyriformis* Ward, Phil. Trans. **183**: 125. 1892. This species is one which easily forms spores at 25° C. in 40–50h; spores are also readily formed in gelatin cultures. This yeast lives with different bacteria in mutualistic symbiosis.—Bay.

Scab (*Oospora scabies* Thax.) on beets reduces their commercial value, although apparently a surface injury, according to analyses made by H. A. Huston (Bulletin Ind. Exper. Station, **5**: 37. 1894). These analyses showed a decrease in the sugar content from 14% in healthy beets to 12.8% in scabby beets in one variety, and from 13.6% to 12.7% in another. Of the beets grown upon the station farm at Lafayette, Ind., some varieties showed at harvest more than half of the beets affected more or less with scab, while none had less than 10% affected.

Baron Ferd. von Mueller has published, under the authority of the Secretary of Agriculture, Australia, an "Illustrated description of thistles, etc., included within the provision of the thistle act of 1890," Melbourne, 1893, pp. 1–20 and twelve plates. The latter show habit and detail figures of *Carduus lanceolatus* (Linn.), *C. arvensis* (Tabernæm.), *C. pycnocephalus* (Jacquin), *C. Marianus* (Linn.), *Onopordon acanthium* (Linn.), *Centaurea calcitrapa* (Linn.), *C. melitensis* (Linn.), *Kentrophyllum lanatum* (Necker), *Xanthium spinosum* (Linn.); which names will give nomenclaturists something to think of! The plates are lithographed and beautifully colored.—Bay.

Tschirch discusses[1] in a late paper the formation of resins and ethereal oils in plants, both from the chemical side and the anatomical. He finds in the epithelial cells of resin passages no trace of resins, so that these are not secreted as such by these cells, but only the resinogenous substances. The resins and oils are, in most cases, first recognizable in the thickened part of the wall of the epithelial cells next the canal. He also discusses the relation between the carbohydrates, phloroglucin, tannins and resins, of which there is a series which is possibly significant of the chemical origin of the resins.

In the *Journal of Botany* (Feb.) Mr. A. Gepp gives a biographical sketch of Richard Spruce, who died Dec. 28th of last year, at the age of seventy-six. From the first of his botanical career he was a special student of mosses and liverworts, and in the last years of his life he devoted himself entirely to the latter, his "Hepaticæ of the Amazon and Andes" probably being his most important contribution. His great service to botanical science consisted in the large collections made during his remarkable and extensive explorations in South America, which were conducted unremittingly from 1849 to 1861. After his return to England in 1864 his life was passed in retirement.

In the *Bull. Torr. Bot. Club* (Jan.) there appear several important papers dealing with our flora. Mrs. Britton presents the N. Am. species of Orthotrichum; Mr. Small begins a series of studies of our S. E. Flora, including in the present paper descriptions of a new

[1] Pringsh. Jahrb. f. wiss. Bot. **25**: 370. 1893.

Amorpha from Ga., and a new Hieracium from Tenn.; Mr. Heller notes twenty-three Virginian species new to the manual range, and describes a new Pentstemon from N. C.; Dr. Britton presents his eighth paper on new or noteworthy N. Am. phanerogams, giving, besides other notes, a synoptical and bibliographical list of the N. Am. species of Stenophyllus, and proposing a new genus, *Meehania*, for *Cedronella cordata* Benth.; Mr. Coville deals with the genus Hemicarpha in N. Am.; and Professor Scribner describes two new grasses.

ANY SUGGESTION that may throw light upon the origin of the higher carbohydrates in plants from carbonic acid is welcome. Bach proposes[1] a hypothesis which has some experimental evidence to support it. It is founded upon a possible analogy with the decomposition of sulphurous acid in sunlight, thus: $3H_2SO_3=2H_2SO_4+H_2O+S$. Similarly: $3H_2CO_3=2H_2CO_4+\boxed{H_2O+C}$. The H_2O+C is formic aldehyde and the H_2CO_4 is supposed to decompose further, thus: $2H_2CO_4=2CO_2+2H_2O_2=2CO_2+2H_2O+O_2$. The experiments show the formation of CH_2O and of H_2CO_4. The rest of the process is hypothetical.

MR. ROSCOE POUND has translated and published in the *American Naturalist* (Feb.) Saccardo's paper at the Genoa Congress on "The Number of Plants." A chronological table is given, running from Hippocrates (500–400 B. C.), who reckons 234 plants, to the estimate of Duchartre (1885), who reckons 125,000 species, of which 100,000 are Phanerogams. By putting together all the recent monographs Saccardo reaches the following result, up to 1892: phanerogams 105,231; ferns 2,819; other pteridophytes 565; mosses 4,609; liverworts 3,041; lichens 5,600; fungi 39,603; algæ 12,178; total 173,706. The author then estimates the probable increase in the total, resulting chiefly from the rapid increase in our knowledge of the fungi, and thinks that we will not go astray in estimating that the flora of the world, when it is completely known, will consist of at least 385,000 species of plants, that is, 250,000 fungi and 135,000 of all other groups. It does seem that those who are describing fungi are rapidly verifying this prediction.

THE BOTANICAL SEMINAR of Washington, D. C., was organized last year, and at present consists of the following members: E. F. Smith, F. V. Coville, B. T. Galloway, Theo. Holm, G. H. Hicks, M. B. Waite, A. F. Woods, D. G. Fairchild, W. T. Swingle, and M. A. Carleton. The Seminar has for its objects, (1) the social intercourse of members; (2) the advancement of botanical knowledge by the presentation of original and other papers, and the free discussion and criticism of the same. The Seminar meets twice a month, at the residences of the members, the meetings, presentation of papers, and discussions being wholly informal. Papers on the following subjects have been recently presented and discussed: Anisophylly in Liquidambar, Sassafras, Vitis, and other plants, Holm; The Hexenbesens of Washington and vicinity, Waite; Some physiological factors influencing the growth of plants in greenhouses, Galloway; Root development in certain plants

[1] Compt. rend. Acad. Sci. Paris **116**: 1145, and 1389. 1893.

of the great plains, Coville; The downward water current in plants, Smith.

In the *Bull. de l'Herb. Boiss.* for February M. John Briquet, who has in preparation a monograph of the Labiatæ, discusses certain questions of nomenclature, chiefly in the light of Dr. Otto Kuntze's recent publications. His purpose is to reply to criticisms and to submit certain matters for consideration by the next international congress. He first considers the question of *nomina nuda* and *nomina seminuda*, rejecting the latter division as useless. To him a name is either valid or not valid, and he would reject any generic name not accompanied by a generic description, considering reference to included species, or exsiccatæ unaccompanied by descriptions, as not sufficient. The second subject is the point of departure for generic nomenclature, in which he scouts the date 1753 on the ground that the Species Plantarum contains no generic descriptions, and insists upon 1737. With considerable elaboration and illustration the status of Rumphius and P. Browne is discussed as to whether they may be considered authors of genera in the Linnæan sense. The so-called genera of Rumphius are declared invalid, as the illustrations seem to abundantly indicate; while those of P. Browne are found to be perfectly logical. In reference to the "once a synonym always a synonym" rule of the Rochester code, M. Briquet shows that it was already in the Paris code, though not so explicitly stated and commonly disregarded, and that "tout le monde doit l'appliquer rétroactivement." A section on the place of pre-Linnæan writings in nomenclature simply raises the point that this question represents a great hiatus in the Paris code, which should be definitely filled up, either by a special article, or by an explanatory note. The author says that pre-Linnæan authors must always be read in order to understand Linæaus, but it is evidently his opinion that they should not enter into nomenclature. The author also considers the question of the nomenclature of subdivisions of species. He regards the genuine variety, which he tries to define, as the only thing worth receiving a name from systematists, all minor subdivisions not being matters of systematic attention, but "biologically" interesting. In conclusion, amendments to the Paris code, embodying the ideas previously set forth, are formally proposed. Among them it is interesting to note the following: That priority of names and of combinations of names shall start from the following dates: 1703 (Ray, *Methodus emendata*), for all the grand subdivisions of the plant kingdom, such as dicotyledons and monocotyledons; 1737 (Linnæus, *Genera*, Ed. 1), for genera and their subdivisions; 1753 (Linnæus, *Species*, Ed. 1), for species and their subdivisions; 1789 (Ant. L. de Jussieu, *Genera*), for families and their subdivisions. The author demands that the next congress, which should be called soon, shall consider amendments to the Paris code "l'une après l'autre," and not vote "en bloc" for a whole scheme, as desired by Dr. Kuntze; and that the propositions to be considered singly are those of J. Müller Arg. (1874), Alph. DC. (1883), O. Kuntze (1891 and 1893), those "en partie singulières" of the American Congress at Madison (1893), and those presented in the present paper. Altogether the paper is a valuable contribution to the already voluminous discussion of nomenclature.